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Research Article

IDENTIFICATION OF FOOT PRINT FOR CRIME SCENE ANALYSIS

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ABSTRACT

Almost in every criminal investigation, it is necessary to determine and prove that a particular person or a number of persons may or may not have been present at the scene of a crime. For this reason, the collection, preservation and analysis of physical evidence have become more frequent in the law enforcement community.

Since criminals must enter and exit the crime scene areas, it should therefore be reasonably assumed that they may leave traces of their footwear. Criminals have become smarter and wiser by beginning to frequently wear protection over their hands to avoid leaving fingerprints and masks over their faces to avoid eyewitness identification. However, they are rarely aware of, or make little attempt to conceal footwear. During an everyday routine it is normal to see an individual wearing gloves, but it is not normal to see individuals wearing protection over their shoes.

Unfortunately, when a crime scene is improperly secured or is disorganized, the search of the scene often results in this type of impression evidence being overlooked or destroyed. But when this type of physical evidence is properly collected and preserved by the crime scene investigator, followed up by a detailed examination and analysis creating necessary database through appropriate image processing implementations, it can become a very important part in proving or disproving whether a suspect was at the crime scene.

INTRODUCTION

In many cases, footwear evidence can lead to positive identifications of which particular known shoe made the print. Footwear evidence can provide investigators with certain information that can assist them in locating a suspect. Most footwear evidence, when collected and preserved properly can provide the type, make, description, approximate size, the number of suspects, the path through and away from the crime scene, the involvement of the evidence, and the events that occurred during the crime.

Footwear impressions are overlooked for two important reasons,

1. The lack of training and education in the proper searching, collection and preservation of the evidence and;
2. The evidence is undervalued or not understood.

The failure to properly collect this type of evidence revolves around the above-mentioned two reasons but the lack of success in finding this evidence is often due to:

1. Not believing that the impressions can be found at the scene after people have walked over the scene
2. Incomplete searches of the crime scene

1. Weather conditions
2. The impression has been intentionally destroyed.

Prior to creating the database with the sample footprints taken from the crime scene, the necessary processes are to be followed:

- Protection of the Scene
- Searching the Crime Scene
- Crime Scene Footwear Evidence

Footwear evidence can be found in two forms, impressions and prints. The impression is normally described as a three-dimensional impression, such as an impression in mud or a soft material; and the print is described as a print made on a solid surface by dust, powder, or a similar medium.

Footwear evidence, as well latent fingerprint evidence, is classified into three categories of crime scene prints:

1. Visible Prints

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2. Plastic Prints
3. Latent Prints

The Visible Prints: A visible print occurs when the footwear steps into a foreign substance and is contaminated by it, and then comes in contact with a clean surface and is pressed onto that surface. This print can be visibly seen by the naked eye without any other aids.

The Plastic Prints: Plastic prints are impressions that occur when the footwear steps into a soft surface, such as deep mud, snow, wet sand, or dirt creating a three-dimensional impression. This type of impression should be photographed and then cast. These types of impressions are three-dimensional because they allow the examiner to see length, width, and depth.

The Latent Prints: Latent prints are the most overlooked print and are generally found on smooth surfaces. They can be developed the same way latent fingerprints are. This type of print needs a variety of powders, chemicals and even forensic light sources to make it visible in order to properly be collected. In most cases these prints should also be photographed prior to any recovery process.

Crime Scene Photographs

Footwear impressions can be located in and outside the crime scene. The crime scene photographs should be taken prior to making any further alterations to the footprints. When the impressions are photographed correctly, they often proved the footwear examiner with more detailed impressions than lifting our custom and thus, resulting in more definite examination and analysis.

Review Works

Euclidian distance between foot-prints was introduced by Nakajima et al. operating on pressure distribution data and simple Euclidian distance, recognition rates of 85% could be achieved [1-3]. Further work concentrates on static and dynamic foot print based recognition using hidden Markov models with recognition rates of about 80 to 97.8% dependent on feature selection and database size [4-6]. Since neither taking ink-based impressions in the first case nor recognition rates of 80 to 85% are suitable for commercial security applications, we investigate more elaborate approaches to foot biometrics. While the idea of using shape and skin texture information of the human hand is not new, it will be more specific for identification the application of some of these features are used in foot biometrics. Traditional hand biometric features are most likely to be applicable to foot biometrics; thus, we investigate their discriminative properties [7-11]. However, techniques also used in face recognition (e.g. Eigen faces) can be successfully implemented. Second, a goal of this project is the introduction of a prototype footprint verification system. Thus if following biometric measurements can be used for identification:

1. Shape and geometrical information focusing on characteristics such as length, shape and area of the silhouette curve, local foot widths, lengths of toes, and angles of inter-toe valleys.
2. Soleprint features analogous to palm print-based verification extracting texture-based information of the sole of the foot.
3. Minutiae-based ball print features employing different techniques used in fingerprint verification systems.
4. Eigen feet feature (corresponding to Eigen faces in traditional face recognition) in the principal component subspace for recognition of both shape and textural information.

Pre-processing is important for reliable foot recognition. Nakajima et al could improve their Euclidian-distance-based footprint recognition method on raw images from roughly 30% to 85% by just achieving normalization in direction and position. While for unconstrained hand images a re-alignment of individual fingers using texture blending is promising, an adaption to foot biometrics is considered complicated due to close-fitting toes and has not yet been implemented. How-ever, a successful alignment of toes could further increase recognition rates of global features. The pre-processing steps are as follows:

1. Binarization using canny edge detection and thresholding.
2. Rotational alignment using statistical moments.
3. Displacement alignment restricting the image to the bounding box of the footprint.
4. Background pixels are masked and the processed footprint is scaled to provide each of feature extractors with appropriate resolution input.

Considering the sole of the foot to be prone to injuries, shape-based features seem also well suited for the foot verification task. One reason for this is that many hand recognition schemes rely on a robust identification of finger tips and finger valleys. When inter finger valleys cannot be detected reliably, a normalization, i.e., correct placement of individual fingers, is hard to achieve. The extraction of these characteristic landmarks is often facilitated by pegs, while more advanced schemes like are peg-free but demand high contrast between background and palm. Since an introduction of pegs is unacceptable for the image acquisition step, and spread toes are not the default case, the reliable detection of inter toe valleys deserves closer attention in foot biometrics.

METHODOLOGY

Image processing is the study of any algorithm that takes an image as input and returns an image as output.
Includes:

1. Image display and printing
2. Image editing and manipulation
3. Image enhancement
4. Feature detection
5. Image compression

foot.png

Suppose A is the file containing image of the foot print. The following figure contains foot print for analysis.

Algorithm

1. If A is of data type uint8, then imwrite outputs 8-bit values.
2. If A is of data type uint16 and the output file format supports 16-bit data (JPEG, PNG, and TIFF), then imwrite outputs 16-bit values. If the output file format does not support 16-bit data, then imwrite returns an error.
3. If A is a grayscale or RGB color image of data type double or single, then imwrite assumes that the dynamic range is [0,1] and automatically scales the data by 255 before writing it to the file as 8-bit values. If the data in A is single, convert A to double before writing to a GIF or TIFF file.
4. If A is of data type logical, then imwrite assumes that the data is a binary image and writes it to the file with a bit depth of 1, if the format allows it. BMP, PNG, or TIFF formats accept binary images as input arrays.
5. If A contains indexed image data, you should additionally specify the map input argument.
6. The following figures show the original image and its corresponding gray scale image.

Original ImageGrayscale Image

Edge Detection Algorithm

Step1:- We need to convert input colour images to gray scale images which is done by eliminating the saturation and hue information while retaining the luminance and the image returns a gray scale colour map.

Step2:- A grayscale or a binary image is taken as its input, and returned a binary image of the same size as binary image with 1's where the function finds edges and 0's elsewhere to find edges of local maxima of the gradient using canny edge detection algorithm.

Step3:- All connected components (objects) that have fewer than certain values pixels are removed from the binary image thus producing another binary image. This is done by the determination of connected components, computation the area of each components, removal small objects. The following figures shows edge detection of original image.

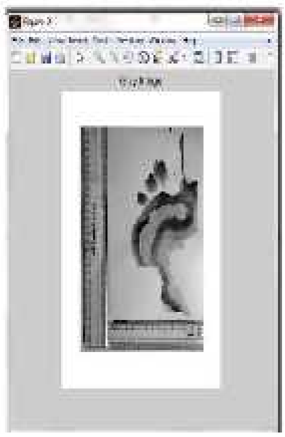
Edge detection

RESULTS

The following steps are implemented to get the final result. The procedure is given below.

Step1: For pre-processing of image, the RGB image first of all is converted into gray scale image which makes the process much easier, because here we need not to maintain three matrices. There is another reason for converting, the input foot print image is on the blood stain.

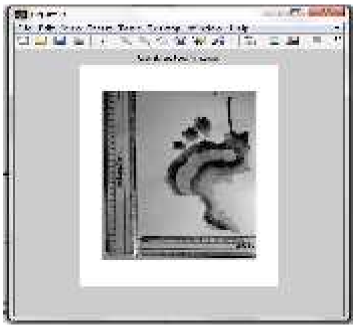
Input Image



Gray Scale Image

Step 2: Next the contrast of the image has been adjusted. As it is not the scanned image therefore the lighting of the image may not be proper. For this reason this step is necessary.

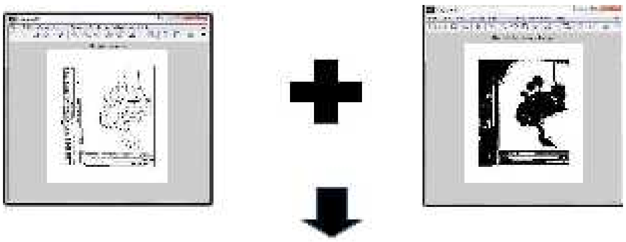
Step 3: Then the Canny Edge detection algorithm is applied to find the edges of the image and also the output image in the form of binary. Although this image is not used for the next steps, it will be used for further biometric identification.



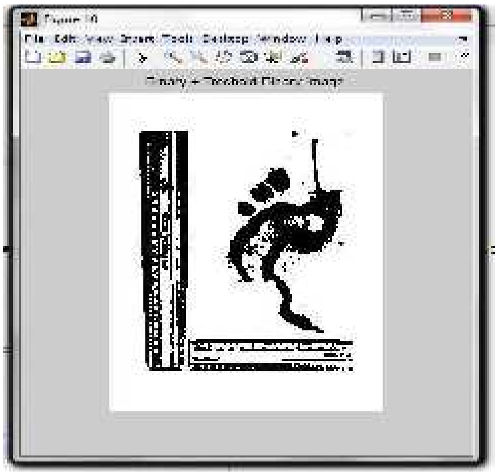
Contrasted Image

Canny Edge Detected

Step 4: Next the gray scale image is converted in to binary image. At the same time another binary image is created using thresholding value. In the next step these two images are added to get more specific image for further processing.

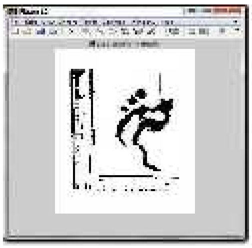


Binary Image **Binary Image using Threshold**

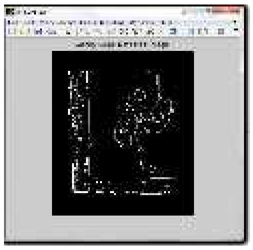


Added image

Step 5: To get more filled image necessary function is to be applied. Here we have drawn small lines to fill the image. Next canny edge detection algorithm can be applied.



Gradient mask



Canny Edge Detected

This system only identifies the left or right foot-print. To detect this, the current processed image is compared to the database image. These database images are processed in the same manner. To get output in short time I have stored these images in database, otherwise processing time will be high. The maximum matches with the database images are checked for identification.

Left Foot

Right Foot

The foot measurements are important in forensic field as they can be used as body height predictors for an individual. The morphology of human feet shows the variations. Determination of personal identity is the first and the most important step in forensic investigations and medicolegal practices.

In anthropological cases, forensic identification is generally carried out through examination of the body or the remains (or prints) from the body. Thus, the feet and footprints become extremely significant, especially when a body is incomplete or unavailable. The finger print recognition, face recognition, hand geometry, is recognition, voice scan, signature, retina scan and several other biometric patterns are being used for recognition of an individual. Human footprint is one of the relatively new physiological biometrics due to its stable and unique characteristics. The texture and foot shape information of footprint offers one of the powerful means in personal recognition.

CONCLUSIONS

Considering that a bloodstained footprint has been obtained from a particular crime scene, a proper photograph of the print is taken by a professional crime investigating officer. Thereafter the photograph is passed through consecutive steps of appropriate image processing so that a suitable database can be created and the obtained footprint becomes easily comparable to another database similarly created having the processed footwear images of the most probable suspects related to the particular crime. Image processing using MATLAB commands is very much advantageous as the original image is first converted to its gray scale format where the analysis can now be suitably carried in only 2 spatial matrices(black and white) instead of 3(RGB, as it is a bloodstained footprint). Moreover conversion of the gray scale image to its canny edge format helps to specify the edge of the footprint that can in turn help in comparisons of the length of two feet, shape or type of shoes etc. Also the binary format conversion of the image deals with the sharp gradients of the footprint thus distinguishing left to right foot, foot of a man to a woman etc. Thus we can see the implementation of image processing has made the analysis and detection of sample footprints much easier. This being a comparatively newer subtrade of criminal detection in the world of Forensic Sciences, footprint analysis using this technology can bring about prominent developments and improvisations in future.

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